

# An investigation into student numeracy across the curriculum

The **NUMERACY ACROSS  
THE CURRICULUM PROJECT  
TEAM** presents findings from  
a Western Australian project  
coordinated by a team from  
Murdoch, Curtin and Edith  
Cowan Universities.

## Introduction

This project has taken the view that numeracy, at the very least, is the ability and willingness to use mathematics to meet the demands of life at home, in education, in paid work, and for participation in the community and civic life (Willis, 1992). If numeracy is about improving students' use of mathematics in life then numeracy education cannot be restricted to the mathematics classroom: students need to apply the mathematics they learn across the curriculum and beyond the classroom. Hence there is more that educators need to find out about how well students can use mathematics in settings other than schools mathematics classes and about the extent and nature of the relationship between students' mathematics knowledge and their capacity to use mathematics in context..

## The project

The project consisted of three main studies:

- a *literature review* identified key issues impacting on numeracy and numeracy education;
- a *quantitative study* of the performance of a sample of approximately 1100 students investigating the existence, strength and quality of the relationship between population basic skills numeracy test scores, student mathematical achievement using both test and school assessments, test scores on a range of numeracy-rich situated test items and observations of similar tasks undertaken in the classroom;
- a *qualitative study* looking at the numeracy that was identified in work across the curriculum in two classes of students in each of eight schools including an in-depth focus on the numeracy learning of three students in each class in each of the eight schools.

In all, eighteen schools were selected to participate in the

quantitative and qualitative studies, six each from the Catholic, independent and state school sectors. The schools were clustered in three research hubs: one city based, and two quite different rural and regional locations. The research focussed on Year 5 and Year 7 in order to maximise access to the population numeracy tests conducted in WA. The project began in August 2001, research in schools was conducted during 2002, with analysis and reporting occurring in 2003.

Underpinning the work was the view that numeracy is more than knowing and doing mathematics in the mathematics lesson. The context and the individual students' handling of the task create the numeracy demands. Therefore to be numerate within a context, students need a blend of mathematical, contextual and strategic 'know-hows' and a capacity to take on the roles of the fluent operator, the learner and the critic (Hogan, 2000).

### A numeracy framework

Being (becoming) numerate then involves a blend of three types of know-how:

<i>mathematical</i>	knowing (or learning) the concepts, procedures and skills which comprise the content of school mathematics;
<i>contextual</i>	knowing (or learning) the meaning and sense of mathematical terms and processes as used within particular contexts;
<i>strategic</i>	having (or developing) the orientations and strategies to manage one's way through routine or non-routine problem situations.

Being (becoming) numerate involves being able (learning to) to take on three roles:

<i>the fluent operator</i>	being (becoming) a fluent user of mathematics in familiar settings;
<i>the learner</i>	having (developing) a capacity for the deliberate use of mathematics to learn;
<i>the critic</i>	having (developing) a capacity to be critical of the mathematics chosen and used.

(Hogan, 2000)

## Findings

The literature review served to guide the work of the teachers and researchers in a range of practical and theoretical ways. The full report contains a detailed discussion of the issues around numeracy, in particular numeracy across the curriculum. Findings from the quantitative study were some-

what mixed, with no clear patterns emerging. Again, the full report deals extensively with these findings. It is the qualitative study that has generated the most interesting and potentially informative results for teachers in the primary years, and it is the findings from this component of the work that is the basis of the rest of this article.

### Numeracy across the curriculum in the primary years

Teachers involved in the project identified and analysed numeracy situations which arose in the classroom. The examples shown in Figure 1 illustrate numeracy demands in a range of situations across the curriculum.

### Two examples

The examples (shown in Figure 2) from the project — both from contexts other than the mathematics classroom — illustrate how the framework can help analyse and learn from what is happening in the classroom

### Student numeracy

These are key findings about students' numeracy in cross-curricular contexts.

- Familiarity with contexts, or a lack of it, matters. Students already familiar with a context were able to engage with and complete tasks with mathematical demands without necessarily being aware of 'doing any mathematics'. They just 'knew' what to do.
- Strategic skills are important. Knowing that mathematics might help, adapting mathematics to the context, knowing how accurate to be, and knowing if the result makes sense in the context.
- The confidence of the student has an impact on their capacity to take up the roles of being numerate. Knowing some mathematics and knowing that mathematics is something that can be used in a range of contexts seems to provide students with confidence. These students are more prepared to have a go, make mistakes and try again.
- It was generally true that whenever mathematical demands were made on students across the curriculum there were some students who had trouble understanding the mathematics involved. Across the whole cohort of students, no one strand from the mathematics curriculum appeared harder or easier.
- Working with other students assists in clarifying problems and solving them. Students discuss and observe peers' strategies. More than that, by working with each other within a learning area and by learning with the teacher, the students learn how 'things are done' and how they are 'dealt with'. This includes how mathematical demands are handled and the 'tricks of the trade'.
- While many of the examples provided opportunities for students to take the roles of a numerate person (i.e., learner, critic and fluent operator) these roles were not generally highlighted, taken up and developed by teachers.

## Teaching strategies for numeracy

An awareness of numeracy across the curriculum generates opportunities for engaging students with the numeracy in tasks. The following strategies were found to be effective in teaching for numeracy.

1. Noticing and dealing with numeracy across the curriculum. For numeracy to be improved it first needs to be identified and then acted on. This can be helped by teaching students about what 'being numerate' involves. Being aware of potential numeracy demands in the curriculum when planning will help the teacher identify possible numeracy moments.
2. Paying attention to and understanding students' numeracy issues. This includes: Listening purposefully, helping students to see the purpose of the learning, giving students the chance to work with others, asking other teachers for advice.
3. Giving time to numeracy (across the curriculum) in the classroom. This includes asking questions about the numeracy, the situation and how they link; asking the students to explain their thinking; giving students the chance to work on numeracy issues; finding another context for students to practise their numeracy once learned in one situation.
4. Reflect on the way mathematics is being taught. Recent research in teaching and learning school mathematics suggests that the way mathematics is taught may impact on how students perceive mathematics, how they learn to use mathematics, how they see the usefulness of mathematics in their lives, their identity as users of mathematics and their capacity to use mathematics in other contexts. It suggests that teacher demonstration and student practice of skills as the dominant pedagogy will limit students' capacity to use mathematics in other contexts.



Figure 1.  
Numeracy demands  
across the primary  
school curriculum.

# Penguin Island

## Mathematical know-how

While scaling their drawings, students needed to draw on their skills and knowledge with measurement and proportion, maintaining shape, relative position and size.

## Contextual know-how

Students needed some understanding of the context of drawing to represent 'depth' and the conventions of perspective drawing. In evaluating their drawings they needed to have a sense of how near was 'good enough.'

## Strategic know-how

The task could be done successfully by comparing the details of various components and using trial and error. Alternatively students could use a more structured approach of dividing their page into smaller areas — a version of the mathematical strategy of breaking problems into sub-problems.

## The Task

Using a Powerpoint® slide and whiteboard, the teacher projected a photograph of a jetty leading to Penguin Island. The students were asked to sketch their own smaller picture of the image. The teacher thought this would be an easy task that built on the students' previous work in Art on background, foreground and middle ground. The task connected with their learning about Penguin Island. However it proved difficult for most students to get started.

## Teaching for numeracy

The teacher began by orienting the students to the context by discussing the relative sizes of different features and the apparent narrowing of the jetty.

The teacher explored, through questioning, the potential mathematics in the task, and the accuracy required to maintain relative size and position, and therefore achieve a suitable level of 'realism' in students' drawings.

After giving students time to tackle the problem themselves, the teacher responded to the students; initial difficulties by drawing some guidelines onto the whiteboard image.

The teacher allowed time for students to suggest different strategies for handling the task. This valued the different approaches and served to recognise the success of those students with less developed number skills who were able to do the task with relative fluency from the start.

## The students

Most students were cast in the role of *learner* by this task. Many had difficulties understanding the concept of perspective. They thought, for example that the far end of the jetty was narrower than the near one. The idea of perspective is very much a part of the context of making pictures that show depth. The conventions that underlie perspective drawing are mathematical in nature, but because of a lack of contextual know-how many students were unable to use their *mathematical know-how* (about position, relative size, scale and so on). They needed to develop some *strategic know-how* through the techniques modelled by the teacher.

Most students did not start out as *fluent operators*. The task provided an opportunity, however, for several students who did not usually demonstrate well developed number skills to approach the task confidently and to demonstrate strong visual and spatial awareness.

# Sheep farming

## Mathematical know-how

Students needed to be able to find out 'how many' — to calculate  $\frac{1}{4}$  of 56 million. They needed to read and understand '56 million' (in terms of place values) and the alternate representation of this as 56 000 000.

## Contextual know-how

They required an appreciation of the fact that there are 'a lot' of sheep in Australia — many millions of them in fact. They were therefore willing to accept the statistic that there are 56 million (and would have been suspect of a figure like 56 thousand if a student had misread a website of statistics on Australia)

## Strategic know-how

Various strategies could be used to work out the number of sheep in the quarter used for meat. This includes working with  $\frac{1}{4}$ , 25% and 0.25. Checking for accuracy by working backwards would also be an advantage. Calculator, pencil and paper and even mental methods would all give good answers.

## The Task

The class was reading an article about sheep farming that included the statistic that 'one quarter of Australian sheep are used for their meat.' The teacher noted that the students appeared to have skimmed over the statistic without engaging with it. S/he realised that students needed to come to grips with the numerical information for true appreciation of the text. To do this they needed to know and understand something of fractions, and that  $\frac{1}{4}$  of a very large number would itself be a large number.

## Teaching for numeracy

The teacher was concerned that the students learn to read more deeply and critically when numerical information is included in passages of text. S/he asked open questions to guide the discussion rather than telling the students 'how to do it (i.e., the maths).' For example, "Is  $\frac{1}{4}$  a lot?"

"How can we work out how many in a quarter?" "What information do we need?" The teacher encouraged students to think through the situation and respond for themselves. As a result, they had the opportunity to practise their numeracy skills and use their mathematics as a tool for learning about a topic across the curriculum. S/he was patient and flexible with time, as some children needed more time than others to fully understand the text and gain confidence in themselves as learners.

## The students

In this instance the teacher intentionally required the students to take on the role of critic as s/he saw that they were not fluent operators with the mathematics needed to deeply understand the text. They needed to read the text carefully and understand the meaning of the mathematical information it contained, in the context of the topic. They discussed the question "Is a quarter a lot?" One student commented that "it depends... Compared to what?" For example,  $\frac{1}{4}$  of 12 is not very many, but  $\frac{1}{4}$  of 20 million is.

The students decided therefore that they needed to find out the number of sheep in Australia. Once some of them found the information that there are 56 million sheep in Australia, they needed some contextual knowledge to judge that this was a reasonable estimate. They then used some mathematical know-how about fractions and number. Also required was some strategic know-how, as the students had probably not encountered fractions with such large numbers previously in their mathematics lessons. The important final step was considering what they had found out about the numbers and how it increased their appreciation of the messages and meanings in the text they were reading — their teacher had explicitly set out for them to be learners about this process and its importance in reading critically, for deep understanding.

Figure 2. The Numeracy Framework in action.



## Questions to encourage critical thinking about mathematics and its use as a tool for learning

### Identify the numeracy

- Can you explain what you are doing?
- Can you tell me what you are thinking as you do that?
- What mathematics did you need to use?

### Use the numeracy

- What information do you need to work it out?
- How could you find out?
- How could you use mathematics to better understand the situation?
- How accurate do you need to be or can you round and estimate in this situation?
- Are there other ways of doing the task?
- Are there other ways of working it out?
- Do you need to learn the mathematics in this situation?
- How is the mathematics in this situation being used?

### Debrief the numeracy

- Was the mathematics used helpful?
- Have you achieved a suitable outcome for this context?
- Does the answer make sense in this situation?
- Where else could you have used this strategy?
- In what other situations could this approach be helpful?
- Did using mathematics help you to better understand to learn about the situation?
- Was using mathematics the best way of dealing with the situation?
- Could a better understanding of some mathematics have helped you with the activity you were doing?

Using such questions as the way you interact with students will help them become more confident and competent users of mathematics in context.

## Teacher development

The teachers in this project were involved in significant professional learning in relation to numeracy across the curriculum. The researchers have also looked at this aspect — the findings are likely to be useful as others explore numeracy across the curriculum.

### What did teachers learn?

Teachers in the project initially viewed numeracy as being about numbers and basic mathematical skills with some awareness of it having relevance to everyday life. Their teaching for numeracy was primarily focussed within the mathematics lesson and minimally included activities to illustrate the relevance of mathematics in everyday situations. They came to recognise the complexity of numeracy as a concept and viewed it as involving more than knowledge of a set of basic mathematical skills. There was a heightened awareness of numeracy occurring across the curriculum and an increased willingness to facilitate students' engagement with the numeracy demands as they occurred. Some teachers

came to see numeracy as important and at times essential for understanding and learning in cross-curricular situations. Teachers became increasingly aware of the need to know what their students were doing in numeracy situations and were interested in the variety of ways in which children tackled these tasks.

### How did they learn?

This project has shown that in teacher development there needs to be:

- a balance between input and action learning;
- time to work through illustrative examples of numeracy across the curriculum in order to see the relevance and applications of the concepts and strategies in teachers' own classrooms;
- teachers need to be equipped and then assisted in supporting their students' numeracy development — ongoing professional development for teachers is a key issue in improving numeracy outcomes for students. This includes time for on going professional reflection and collegial discussion;
- time given for new ideas to become incorporated into thinking.

## Conclusion and future directions

This ambitious study has yielded some practical advice that will be useful to many teachers and schools as they grapple with the issues around developing students' numeracy across the curriculum. Clearly there is a lot left to do; the following have been identified as some directions for work on numeracy across the curriculum in primary schools:

- developing a practical 'whole school' approach to numeracy across the curriculum;
- developing numeracy in the middle years through sharing good practice;
- developing innovative numeracy assessment strategies.

## References

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